Evaluating GXS Impact in the Context of International Coordination

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# Why use hyperspectral IR from geostationary orbit?

Low Earth Orbit (LEO) hyperspectral radiances from instruments such as CrIS, AIRS, and IASI are essential to NWP (among many other applications!), providing high vertical resolution T and humidity information, but limited horizontal and temporal resolution

- Orbital gaps leave regions unobserved
- Difficult to view gaps between clouds
- Limited ability to monitor rapidly evolving phenomena

Many of these issues are resolved by a GEO orbit!

McCarty et al., 2021; Schmit et al., 2009

GeoXO Sounder (GXS)
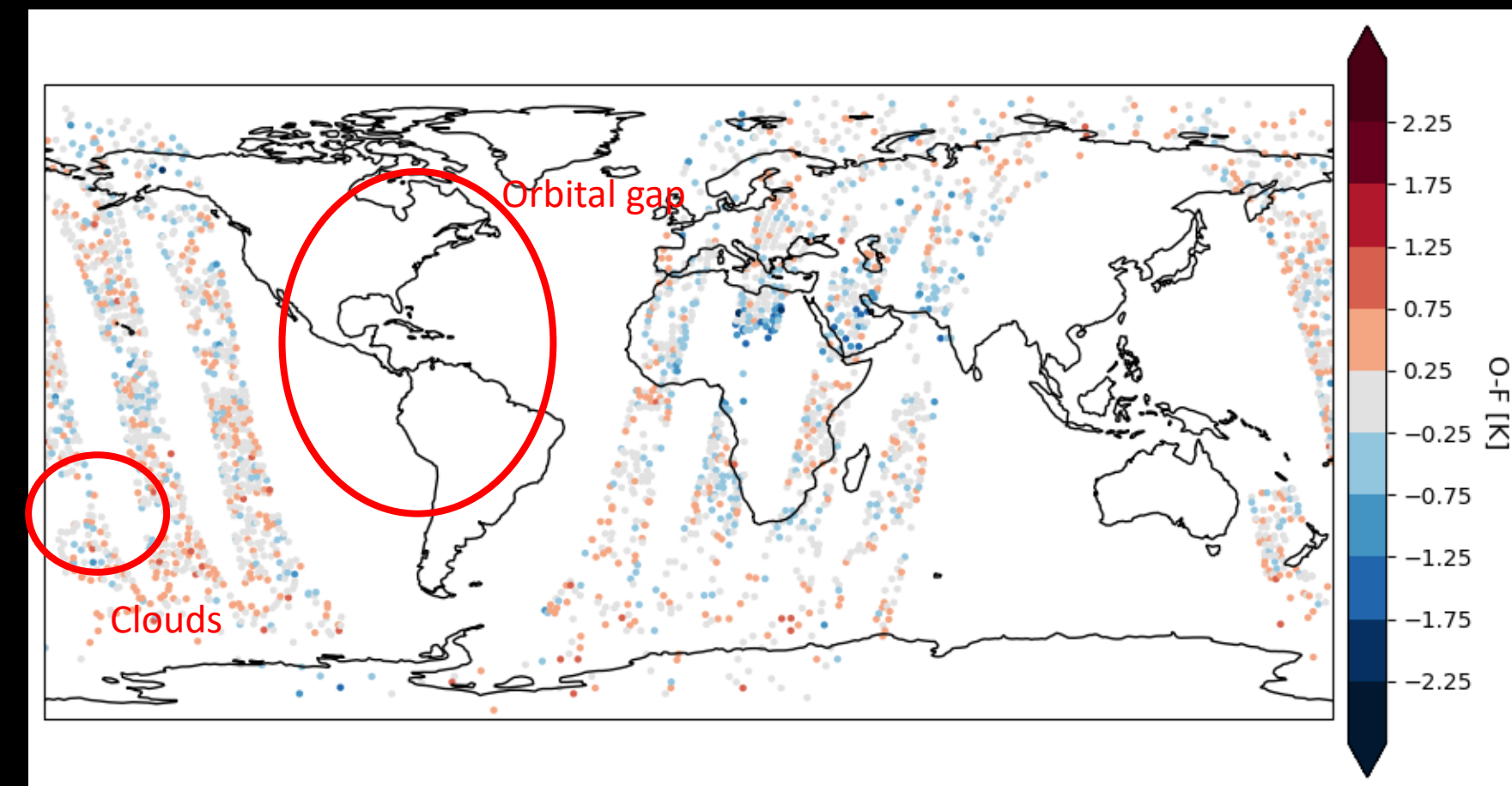
GeoXO program has proposed adding a sounder on a new central satellite as the United States' contribution to the WMO's vision for a global ring of hyperspectral IR sounders by 2040

Allow improved horizontal, vertical, and temporal resolution observations of the atmosphere and more opportunities to view between clouds and observe rapidly evolving phenomena with a lower data latency

Proposed channels for GXS range from 680 to 2250 cm^{-1}

Expected launch in 2035

September 2023, NOAA selected Ball Aerospace to build the instrument

GEO-Central
Hyperspectral Infrared Sounder
Atmospheric Composition
Partner Payload

What is a traditional OSSE?

Completely simulated environment to test hypothetical impact of proposed instruments, comprised of 3 components:

1. Nature Run – the "truth"
2. Simulated observations from the Nature Run
3. NWP data assimilation system

One advantage of a traditional OSSE: error may be computed explicitly since the "truth" is fully known
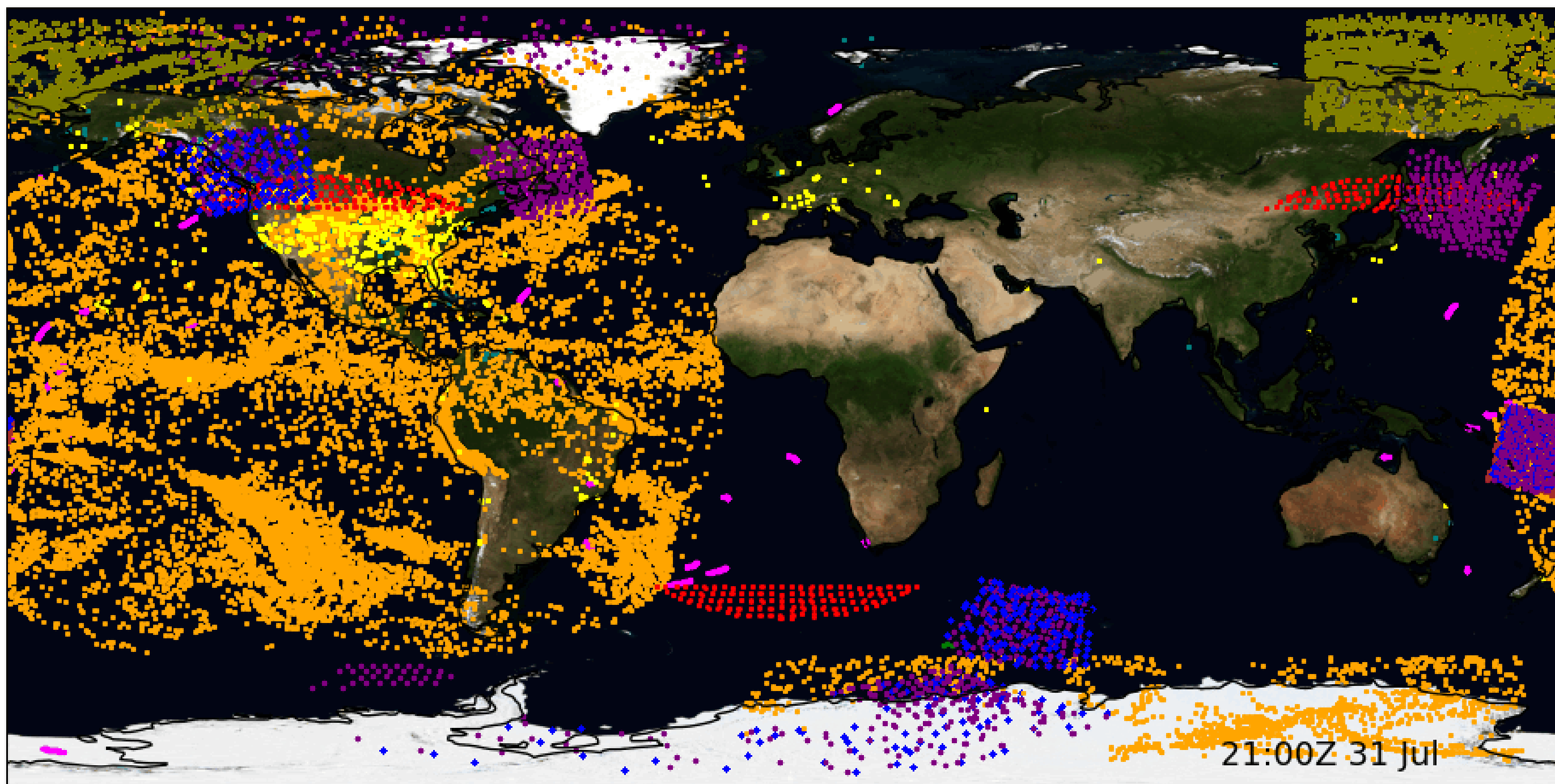
Use the GMAO Nature Run

Observing system based on July – September 2020
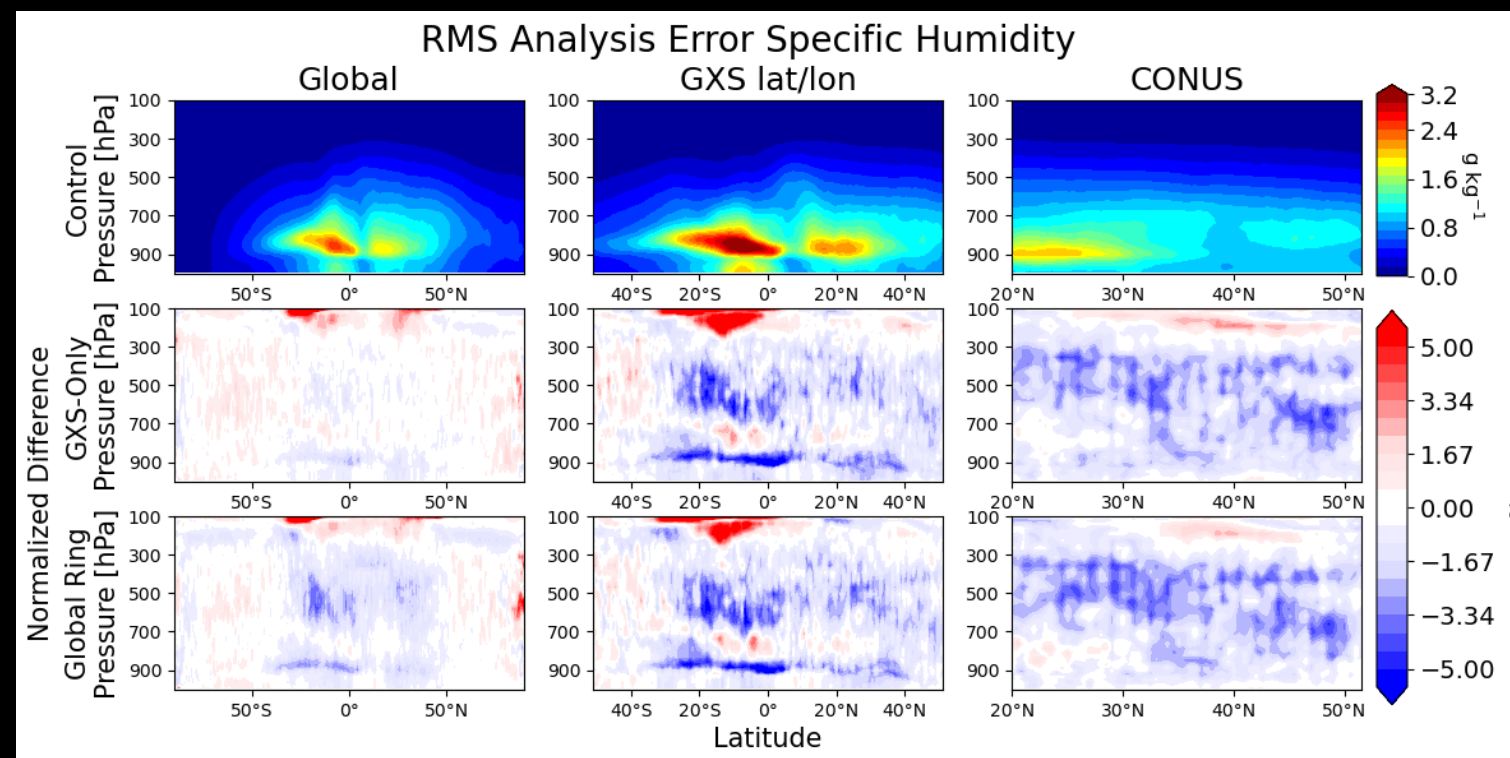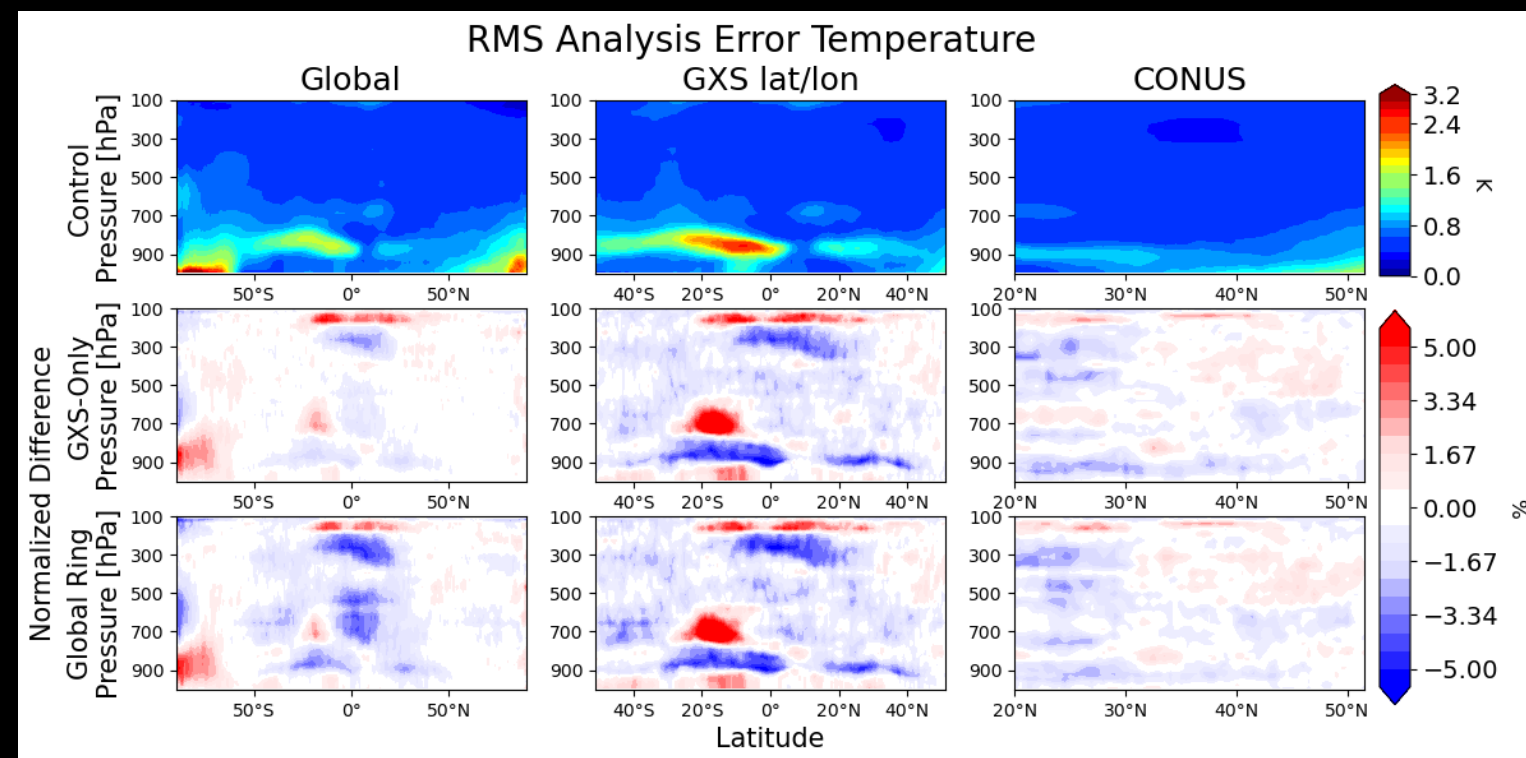
3 experiments

1.   Control (2020 observing system)
2.   GXS-Only (Control + "GeoXO GXS")
3.   Global Ring (Control + "GeoXO GXS" + "MTG-IRS" + "Himawari-10 GHMS")

GXS, IRS, and GHMS are IDENTICAL in these simulations, but sample the NR at different spatiotemporal locations
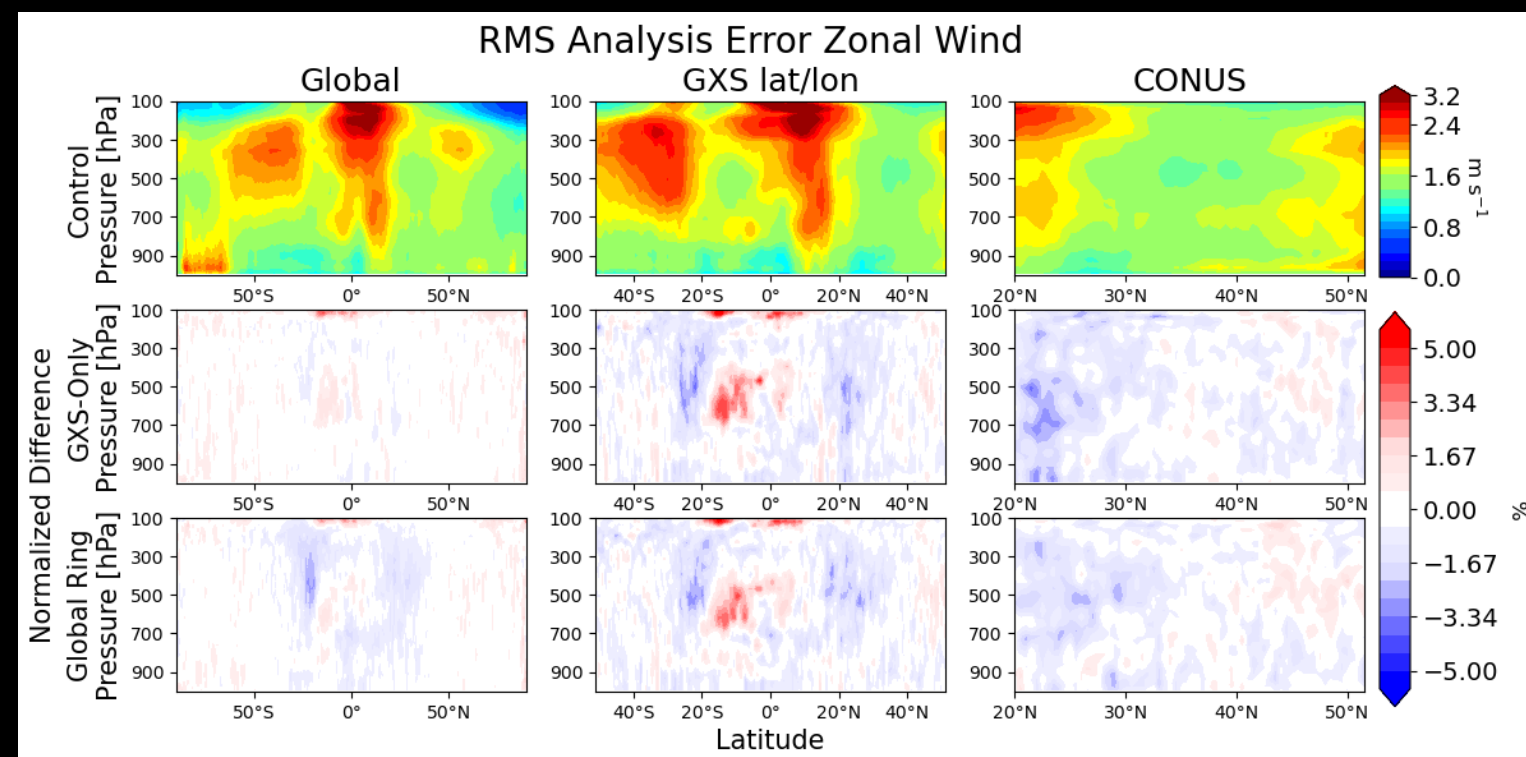
Observations in GMAO's GEOS

RMS Analysis Error Temperature

RMS Analysis Error Specific Humidity
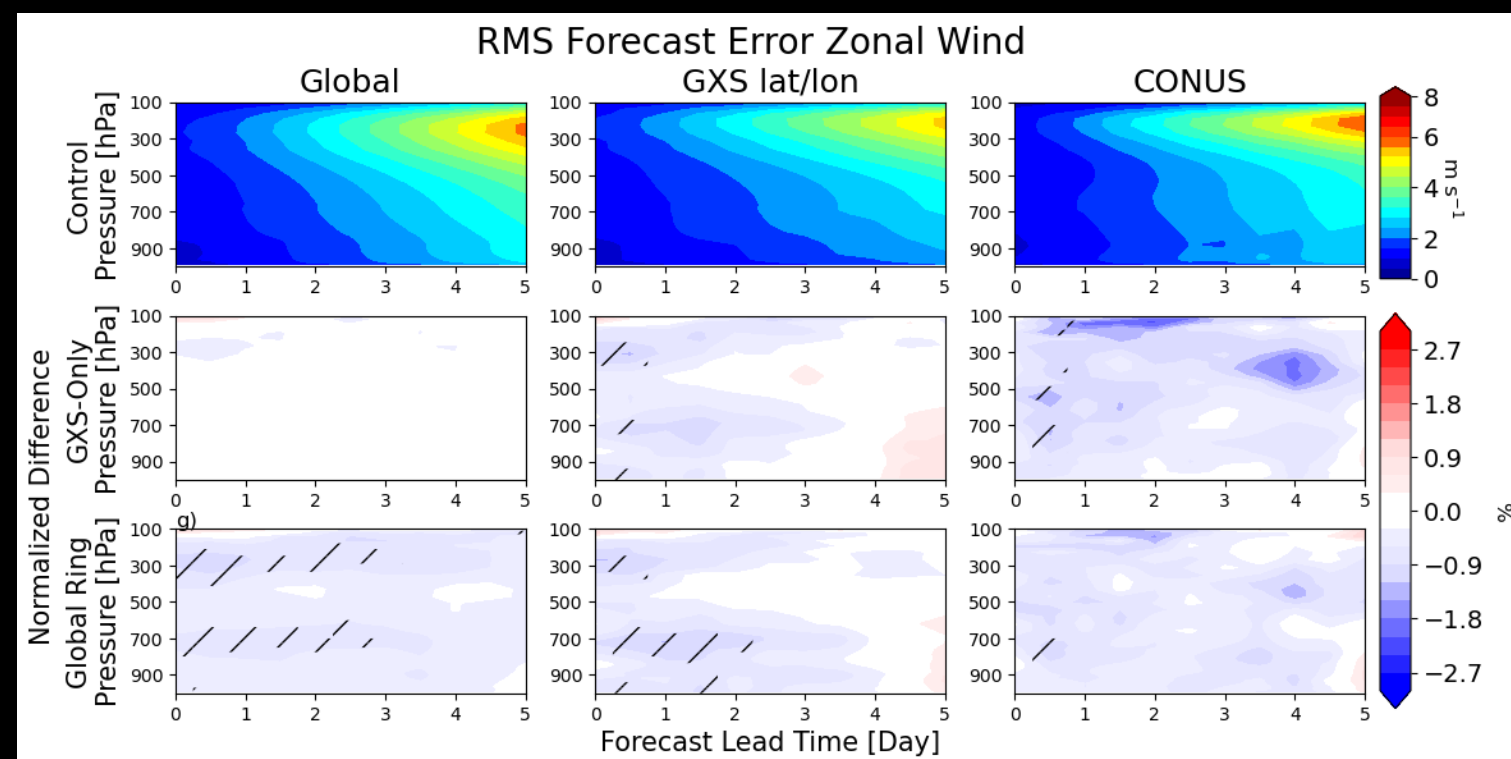
RMS Analysis Error Zonal Wind

Improvement

Degradation

- Top: RMS error in Control; Middle: Normalized Difference GXS-Only; Bottom: Normalized Difference Global Ring

- Impact largest in the tropics

- Globally, beneficial impact is magnified for the Global Ring

- Regionally the impact is mostly from GXS with minimal differences attributed to the Global Ring
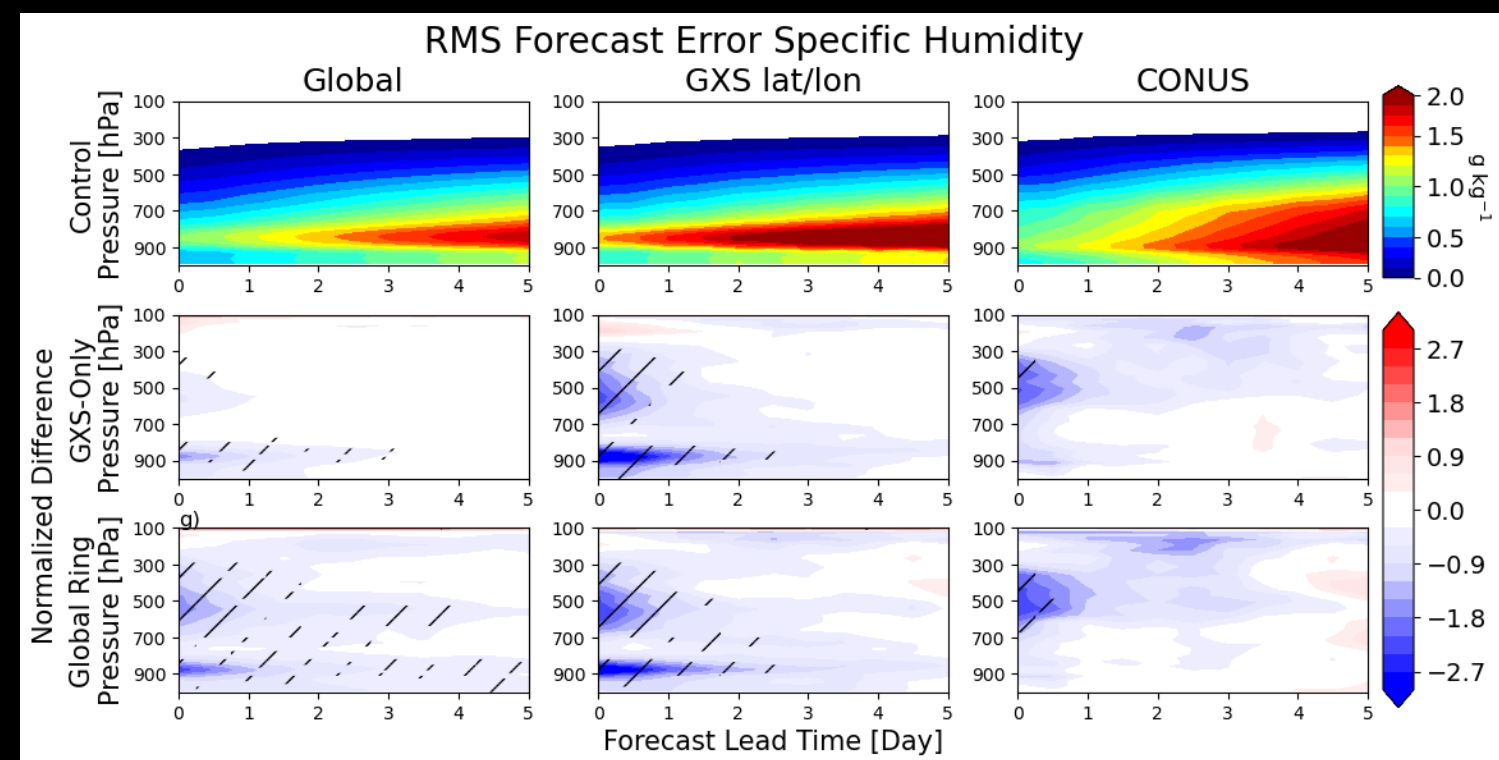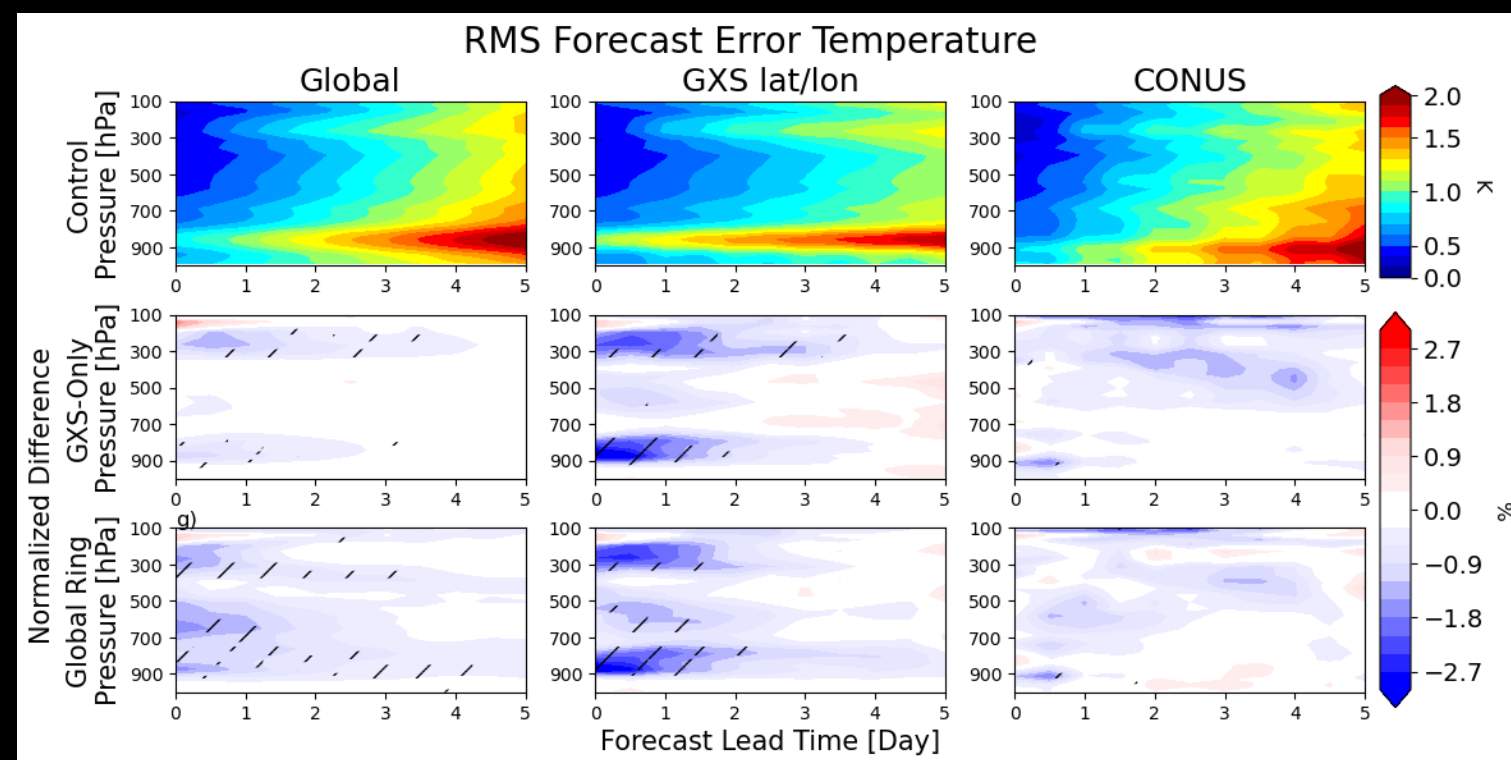
Improvement
Degradation
90% significance

- Top: RMS error in Control; Middle: Normalized Difference GXS-Only; Bottom: Normalized Difference Global Ring
- Initialized by analyses so an improved analysis results in improved forecast
- Global beneficial impact magnified and with longer duration when Global Ring assimilated
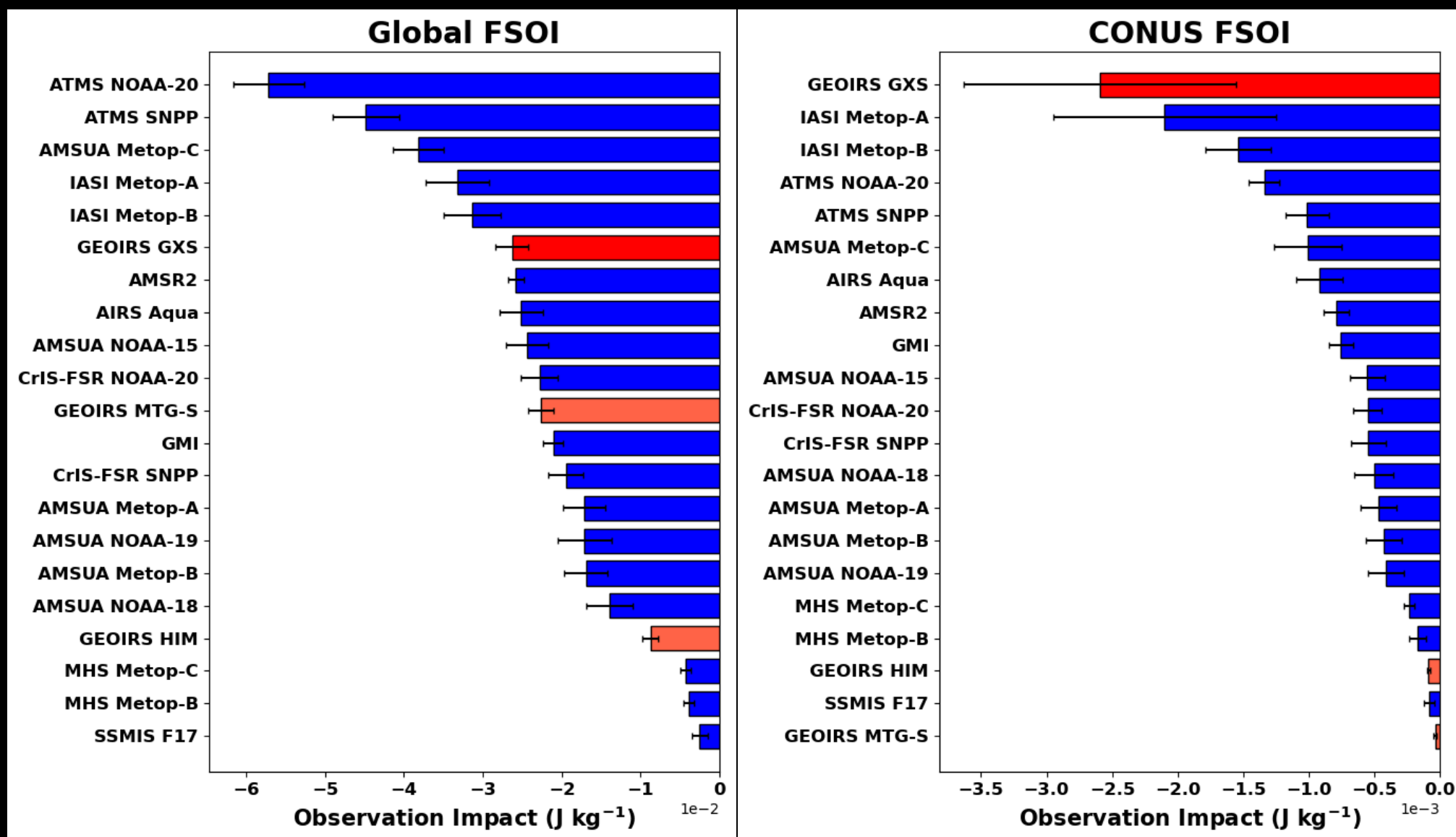- Regionally the beneficial impact attributed mostly to GXS assimilation
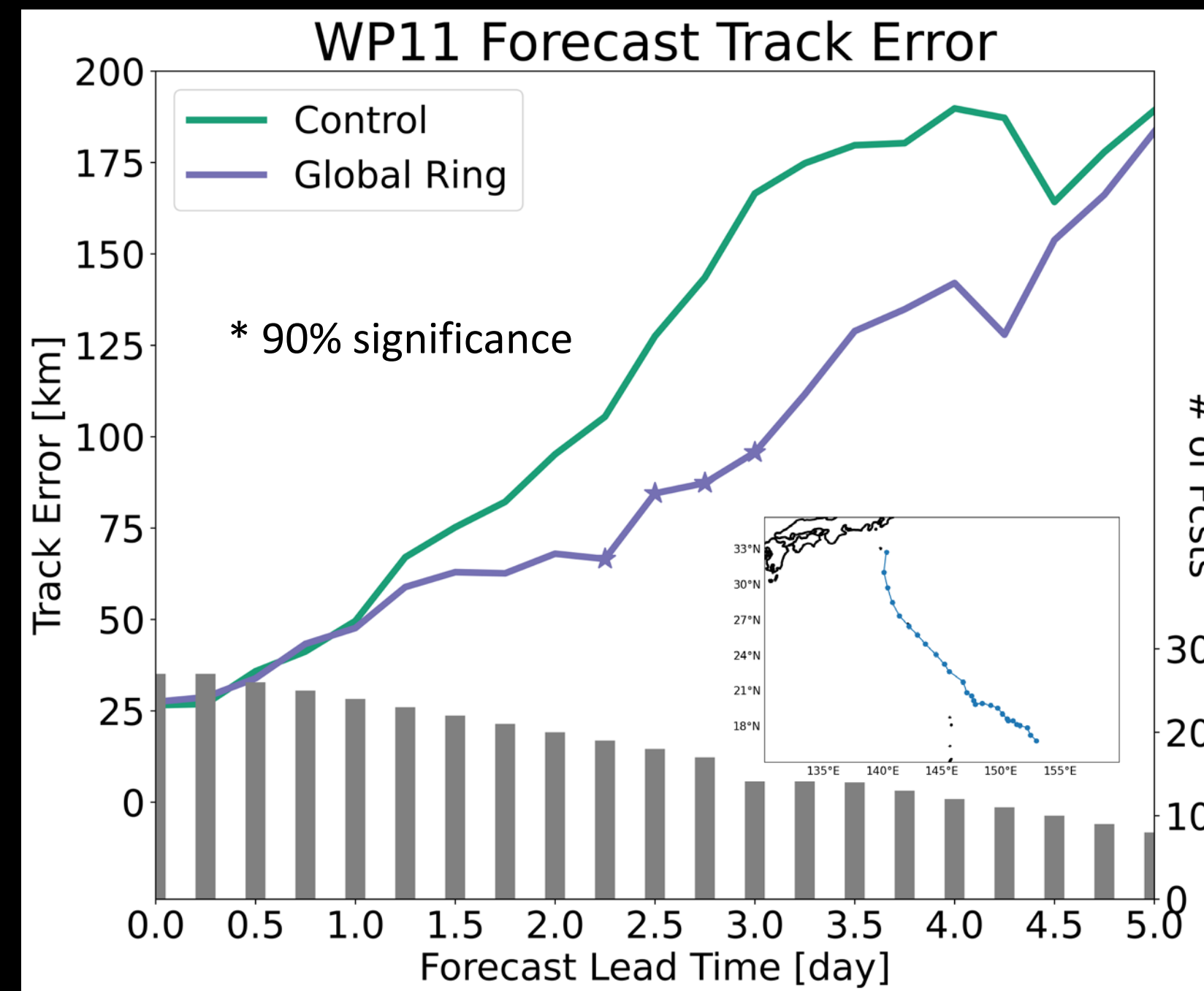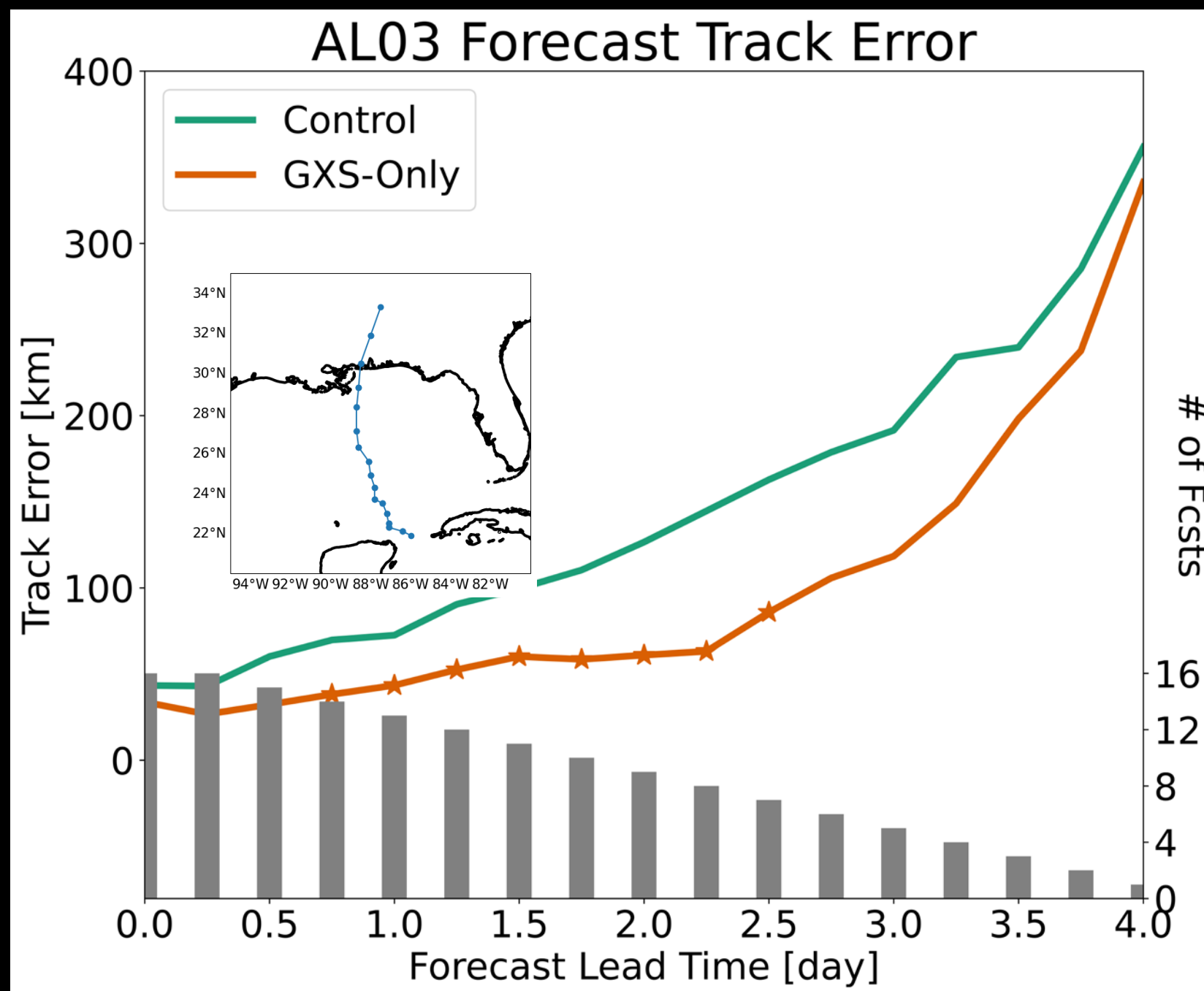
Forecasted track improved for Atlantic and West Pacific tropical cyclones observed by geostationary sounders

Statistically significant improvement on the order of 1-3.5 days, timeframe relevant for evacuations

Hurricane forecast

Global FSOI

CONUS FSOI
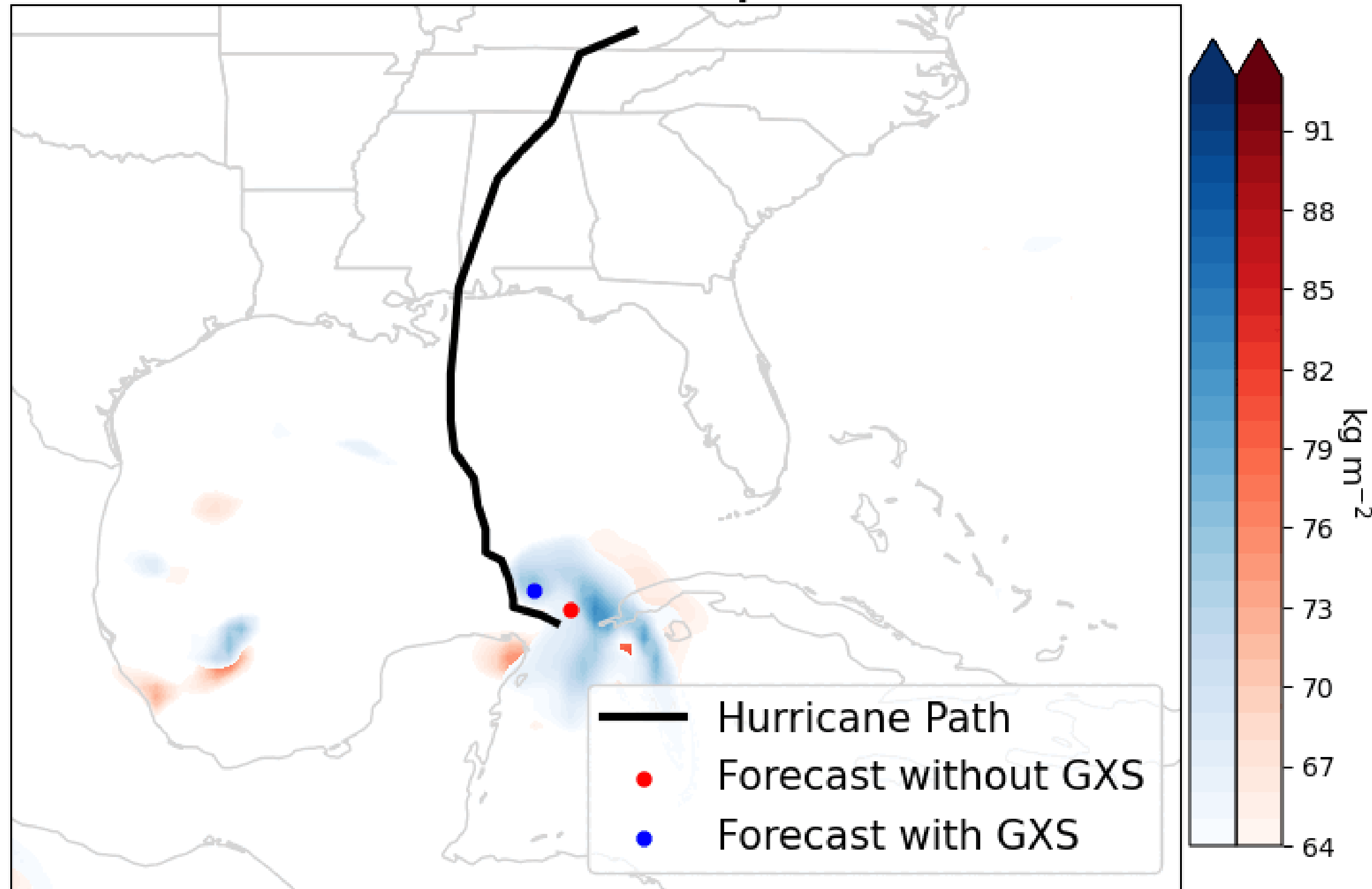
- **Forecast Sensitivity Observation Impact (FSOI)** shows how each satellite reduces the 24-hour forecast error
  - This metric provides a generalized grouping of high-impact instrumentation
  - Globally, polar orbiters have a strong impact on reducing the total wet energy norm error
- **Regional FSOI** shows how each satellite reduces the 24-hour forecast error over CONUS
  - GeoXO program is interested in improving the forecast over CONUS
  - Regional metric computed for all 4 synoptic times shows temporal resolution advantage of geostationary orbit

Summary

International collaboration is critical to improving global NWP analyses and forecasts

GXS is responsible for most error reductions beyond the Control over GXS-observed domains

Hurricane forecast track improvement possible from GEO IR assimilation

Globally, GXS is middle of the pack in wet energy error norm reduction, partially due to limited global spatial coverage

But over CONUS, the high temporal resolution GXS does the most work at error reduction

Thank you!

For more information on GXS, please visit
https://www.nesdis.noaa.gov/our-satellites/future-programs/geoxo/geoxo-sounder-gxs